Dilution Ventilation: Concentration Buildup

**Category:**
Ventilation

**Units**
- \( \ln \) = the natural logarithm
- \( G \) = the generation rate of a gas or vapor (cfm)
- \( Q' \) = the effective flow rate of dilution air (cfm)
- \( V_r \) = the room volume (ft³)
- \( C_{g1}, C_{g2} \) = the initial/final airborne concentrations, respectively, of a contaminant in the decimal equivalent of parts per million (PPM/10⁶)
- \( t_{1, 2} \) = the initial and final times, respectively, for \( C_{g1}, C_{g2} \) (min)

\[
\ln \left( \frac{G - Q' C_{g2}}{G - Q' C_{g1}} \right) = \frac{Q(t_2 - t_1)}{V_r}
\]

**Reference:**

**Theory and Application**
Dilution ventilation is a method of controlling the level of airborne contaminants to some acceptable room concentration by introducing fresh, uncontaminated outside air to the space to dilute and maintain a desired room concentration. This method of control must be limited to low toxicity contaminants that are generated at a relatively uniform rate and sufficiently away from a worker’s breathing zone.

This equation describes the relationship between the concentration buildup of a contaminant that is still actively being generated at any time, \( t \), for a given room volume, with/without an initial room concentration, and effective volumetric dilution flow rate, \( Q' \). The concentration after a certain time interval (\( \Delta t \) which equals \( t_{2} - t_{1} \)) can be calculated by solving for \( C_{g2} \). The effective ventilation flow rate does not incorporate a safety factor to account for incomplete mixing of the contaminant with room air. Safety factors, based on professional judgement, generally range from 1 to 10 times the amount of dilution air calculated to account for incomplete room mixing.

This equation has additional discussion in

**Example**
What is the final room concentration of toluene after 10 minutes if the vapor is generated at a rate of 5 cfm in a room 20 feet wide, 40 feet long and 12 feet high which measured an initial concentration of 50 ppm while being ventilated with clean dilution air at a flow of 2,500 cfm?

\[
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\]

\[
\ln \left( \frac{5\text{cfm}-2,500\text{cfm}(C_{g2})}{5\text{cfm}-2,500\text{cfm}(0.00005)} \right) = \frac{2,500\text{cfm}(10\text{min})}{9,600\text{ft}^3}
\]

\[
\ln \left( \frac{5\text{cfm}-2,500\text{cfm}(0.001856)}{4.88\text{cfm}} \right) = 2.60
\]

\[ e^{2.60} = 0.0743 \]
\[ C_{g2} = 0.001856 \times 10^6 \text{(convert to ppm)} \]
\[ C_{g2} = 1,856 \text{ppm} \]